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Advanced Laboratory Solutions Consulting, LLC

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Types of Hydrogen

Brown hydrogen – made from coal, CO_2 is emitted into the atmosphere.

Grey hydrogen – made from natural gas or coal, CO_2 is emitted into the atmosphere.

Blue hydrogen – made from natural gas, most CO_2 is captured and stored.

Green hydrogen – produced using electricity from renewable energy sources to power an electrolyzer to turn water into hydrogen and oxygen. No CO_2 is emitted.

Did You Know?

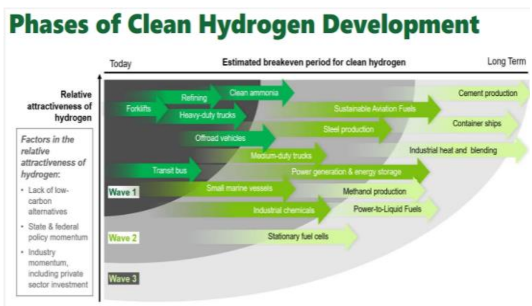
Steam-methane (CH_4) reforming of natural gas is the current leading technology to produce hydrogen in large quantitites.

Hydrogen as a Fuel

Today, hydrogen (H_2) is mainly used as a feedstock for the petrochemical, food, electronics and metallurgical processing industries, with ~10 MMT produced per year in the US. Not all types of hydrogen are the same, ranging from brown to green hydrogen, with blue and green hydrogen considered "clean" hydrogen.

The use of clean hydrogen in fuel cells within the transportation sector is expected to grow rapidly over the next 10 – 30 years, with 50 MMT/year projected by 2050.[1] To meet this expected new demand, three phases of clean hydrogen development are envisioned:

- The first wave – existing markets that have few alternatives to clean hydrogen for decarbonization.
- The second wave – applications where clean hydrogen and its economic value proposition is supported by industry commitments and policy advancements.
- The third wave – uses that will become competitive as clean hydrogen production scales significantly, and associated costs decline as infrastructure becomes more prevalent.[1]



Phases of Development[1]

[1]clean-hydrogen-strategy-roadmap.pdf
[2]H2Houston Hub — Center for Houston's Future (centerforhoustonsfuture.org)

In addition to fuel cell use, hydrogen will be an essential feedstock for biofuels including sustainable aviation fuel (SAF) and power-to-liquid (PTL) fuels, and can displace natural gas in difficult-to-electrify sectors requiring high-temperature heat.

Legislatively, the Department of Energy (DOE) is promoting the establishment of regional networks with hydrogen "hubs" located therein, with the goal to co-locate large-scale clean hydrogen production with multiple end-uses in an effort to foster low-cost production utilizing existing infrastructure. The DOE is statutorily required within this legislation to fund hubs in fossil-intensive regions.

The Texas region (Texas and Lousiana) and Houston, TX specifically, is a leading contender for a hydrogen hub. Many factors give TX significant advantages:[2]

- Access to abundant renewable power generation and low-cost natural gas
- Existing H_2 production capacity
- Favorable geological formations for storing H_2 and carbon dioxide (CO_2)
- Extensive oil & gas & hydrogen pipelines

The Midwest region encompassing Illinois, Indiana, Kentucky, Michigan, Minnesota, Ohio and Wisconsin has its own comparative advantages:[2]

- Feedstock diversity
- Existing hydrogen infrastructure
- End-use diversity
- Agriculture (ammonia)
- Critical industrial and manufacturing hub

The DOE plans to announce projects selected for Hydrogen Hub funding in the fall 2023.

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Emerging Drop-in Fuels

- Renewable Diesel
- Sustainable Aviation Fuel (SAF)
- Renewable Natural Gas (RNG or Biogas)
- Biobutanol
- Methanol
- Renewable Gasoline

Renewable Diesel Production

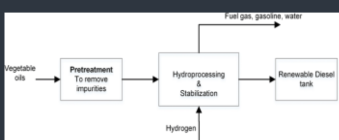
Renewable diesel reactions consume a significant amount of hydrogen.

Refineries with excess hydrogen capacity are good candidates for conversion to renewable diesel production.

When hydrogen is absent, renewable feedstocks can polymerize causing gumming and fouling of equipment.[3]

Hydrotreater reactions in renewable diesel production are far more exothermic than petroleum diesel desulfurization reactions.

This increase in reaction exothermic release limits renewable diesel production by approximately a factor of 10 that of petroleum diesel.[3]



Renewable Diesel Production

Renewable Diesel

Renewable diesel and biodiesel are not the same. Biodiesel, a mono-alkyl ester produced via transesterification, meets ASTM D6751 and is approved for blending with petroleum diesel. Renewable diesel, a hydrocarbon produced from hydrotreating and via gasification, pyrolysis, and other biochemical and thermochemical technologies,[3] is chemically identical to petroleum diesel and as such, can be used as a direct drop-in replacement without any changes to an existing engine.

Renewable diesel is made from hydroprocessing of animal fats, vegetable oils and used cooking oils and as such, is considered a sustainable fuel which produces lower emissions of up to 85% that of traditional petroleum diesel.[4]

Unlike biodiesel, the range of feedstock sources for renewable diesel is vast and still being explored. The sources range from municipal solid waste to corn stover, fatty acid waste, and corn ethanol bottoms.

Triglyceride feedstock high in free fatty acids, which limits their commercial use for biofuels production, is particularly attractive for renewable diesel production due to their lower price, and any common triglyceride source can be used provided suitable pretreatment is performed to remove catalyst poisons and inhibitors.[5] However, these common triglycerides can create a corrosive environment and may require either separate pre-heat trains or an update to the feed-side metallurgy[3] when modifying a refinery for renewable fuels production. Additionally, extra consideration must be taken to handle the much larger quantities of water and CO_2 that are produced in renewable diesel reactions.

Sustainable Aviation Fuel (SAF)

SAF is made from renewable biomass and waste resources and has similar properties to conventional jet fuel. SAF is produced utilizing a variety of technologies to break down the biomass and waste resources for recombination into energy-dense hydrocarbons. Some emerging SAFs are produced using wastes such as food waste, animal manure, and other wastes with high water content, while still others are produced from bio-acetone or waste carbon monoxide.[6]

Renewable Natural Gas (RNG)

RNG, or biogas that has been upgraded for use, comes from a variety of sources including municipal solid waste landfills, wastewater treatment plants, livestock farms, and food and organic waste operations.[7]

Raw biogas has a methane content of 45-65% and with a series of treatment steps, has a methane content of 90% and higher.

Biobutanol

Produced from similar feedstocks as ethanol, biobutanol commercialization centers on isobutanol for blending with gasoline.[8]

Methanol

An alternative fuel produced by steam-reforming natural gas to syn gas and then reacting with a catalyst to produce methanol and water vapor. Methanol can be manufactured from a variety of feedstocks such as biomass, natural gas, and coal.[8]

Renewable Gasoline

Various biomass sources such as vegetable oils, greases, crop residues and woody biomass can be used to produce renewable gasoline via methods including, but not limited to, hydrotreating, gasification and pyrolysis.[8]

Similar to renewable diesel, renewable gasoline is chemically identical to its petroleum counterpart, and can be used as a direct replacement in existing vehicles with no modification of existing engines required. Renewable gasoline meets ASTM D4814 specification as petroleum gasoline, and with the variety of feedstocks available, can reduce CO_2 emissions over traditional gasoline.

Summary

From hydrogen to the emerging drop-in fuels, it is clear the direction many are going – replacement of petroleum fuels with those produced from renewable resources such as animal fats and municipal solid waste.

As consistent throughout many technological advancement cycles, this alternatively sourced fuel will advance as production efficiency, utilization, and storage improves and costs decrease.

Advanced Laboratory Solutions Consulting, LLC will follow the advancements and periodically report our findings in future newsletters – be sure to subscribe today!

[3]Converting a Petroleum Diesel Refinery for Renewable Diesel (hubspotusercontent-na1.net)

[4]What is Renewable Diesel? - PacStatesPetro

[5]https://blog.burnsmcd.com/renewable-diesel-feedstocks-pretreatment-and-purification

[6]Sustainable Aviation Fuels | Department of Energy

[7]Renewable Natural Gas | US EPA

[8]Alternative Fuels Data Center: Emerging Fuels (energy.gov)

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